Technology Sub-Discussion Group Status Report

Greg Follen, Bill Haller

November 6-7, 2012
EDG Executive Committee Meeting

Presentation Outline

- Organizational Updates
- FY13 Plans/Status
- Identification of issues/needs
- Summary

SC Organizational Updates

2013 Membership	
Greg Follen (NASA Co-Chair)	Muni Majjigi (GEAE)
Bill Haller (NASA Co-Chair)	James Hileman (FAA)
Will Dodds (GEAE)	Sandy Webb (Environmental Assistant)
Dom Sepulveda (PW)	John Whurr (Rolls Royce)
Don Weir (Honeywell)	Dan Allyn (Boeing)
Jia Yu (Goodrich)	Arthur Rypinski (OST)
Costas Baltas (PW)	Terry Thompson (Metron)
Mike Marcolini (NASA)	Joe DiPardo (FAA)
Warren Gillette (FAA)	Michelle Kirby (Georgia Tech)
Edward McQueen (FAA)	
William Herkes (Boeing)	

FY12 Plans

The FY12 activities will emphasize 2020-2035 technologies for reduced emissions, noise and increased fuel burn. Investigate the effect of alternative fuels and associated technologies on emissions.

- Maintain coordination with Operations Standing Committee
- Assess and refine Alternative Fuels impact to Emissions and Fuel Burn in the Technology Standing Committee's Table 1 & Table 1-1(Alt Fuels) Targets.
- Continue to evaluate most promising Technologies that impact Noise, Emissions, Fuel Burn Targets
- Develop initial Table 2 targets by seat class for 2020-2035.

FY12 Plans	Status
Maintain coordination with Operations Standing Committee	On Going
Assess and refine Alternative Fuels impact to Emissions and Fuel Burn in the Technology Standing Committee's Table 1 & Table 1-1(Alt Fuels) Targets.	See charts 6-13
Continue to evaluate most promising Technologies that impact Noise, Emissions, Fuel Burn Targets	Monitoring NASA ARMD, CAEP, AEC, CAAFI
Develop initial Table 2 targets by seat class for 2020-2035.	Deferred for now

FY12 Additional Status

1) TSC did socialize idea of EDG with the TSC. General consensus was to continue but there was some skepticism as to the effectiveness the group will have. We have had a few telecoms on the IPSA question (item #3) but that is all.
2) Monitoring the NASA Fundamental Aeronautics Program Fixed Wing Project ACCESS Flight test activity which is the follow on to AAFEX II continuing with examination of alternative fuels using same suite of alt fuels analyzed in AAFEX II but now measured in flight by chase plane. Flight Scheduled for FY13. See charts 6-12.
3) Regarding Emissions, Noise, Fuel Burn: targets will be to develop for 2020-2035
    1) Obtained CAEP WG3 Emissions report (Toulouse). Intend to discuss with TSC;
    2) Monitoring CAEP Noise WG, through Dennis Huff, NASA GRC;
        1) The ICAO CAEP/9 Independent Expert Panel (IEP) for noise has been working over the past year to evaluate novel aircraft/engine concepts and update noise goals for mid-term (2020) and long-term (2030) EIS. Novel concepts include open rotors, UHB turbofans, and advanced vehicles studied in the United States and Europe. Noise margins relative to Chapter 4 were estimated for future regional jets, short-medium range jets, long range twin jets, and long range quad jets. Detailed studies were conducted for counter-rotating open rotors and large turboprops. A final report has been completed that will be submitted to ICAO in November. A summary of the results will be presented at CAEP/9 in February.
    3) Will coordinate with Mike Marcolini on IPSA-TSC analyses. See chart 13.

The Alternative Aviation Fuels Experiment (AAFEX II)

Objectives

- Evaluate engine performance with alternative fuels
- Determine the effects of alternative fuels and ambient conditions on particulates and gas phase emissions
- Study volatile aerosols that condense in plume and impact of fuel composition

Fuels Evaluated

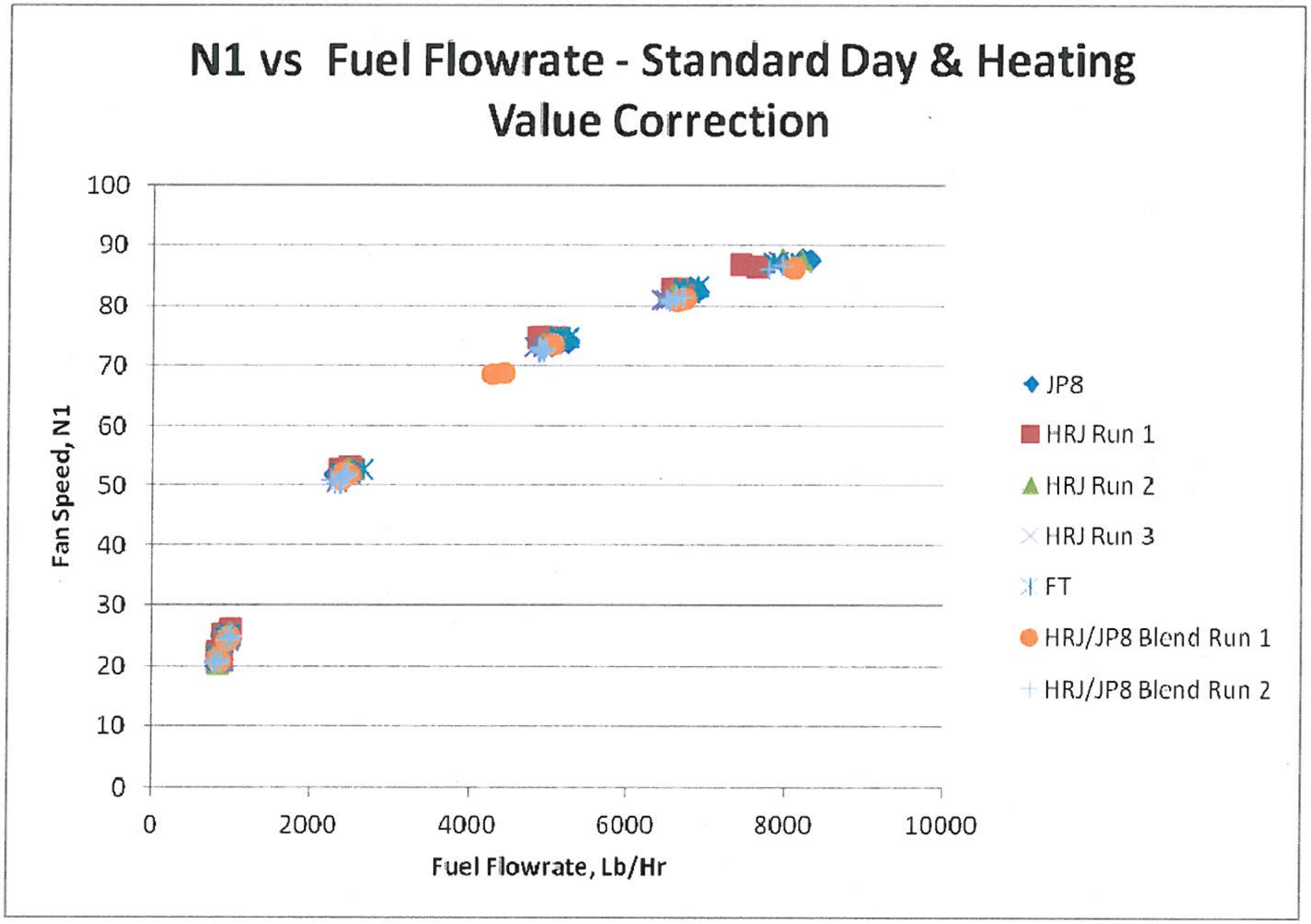
•JP-8
•JP-8/HRJ Blend
•Tallow HRJ
•Sasol FT (coal)
•Sasol FT + ~1000 ppm sulfur

Engine Conditions

•4%, 7%, 30%, 65%, 85%, 100% of rated thrust

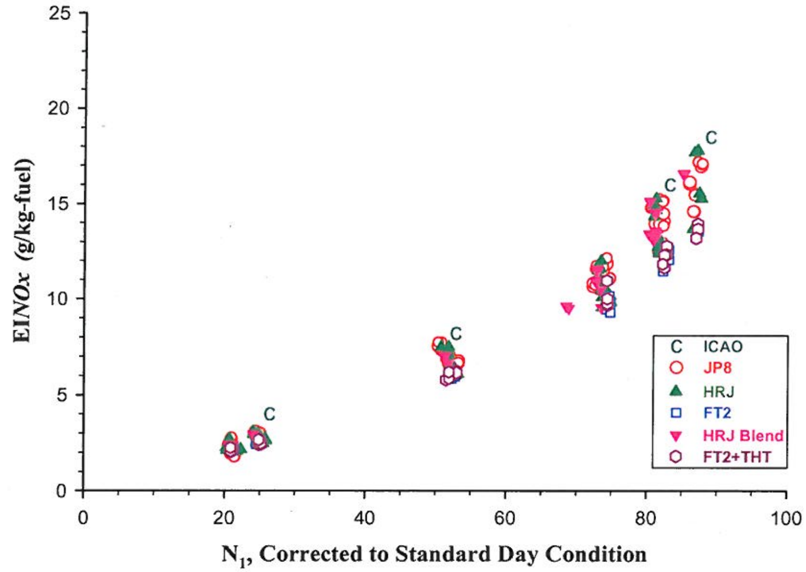
NASA DC-8 Aircraft with CFM56-2C Engines

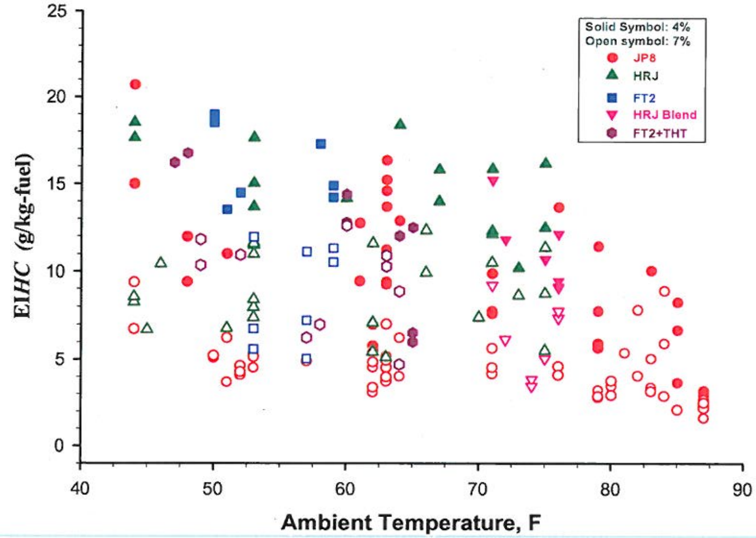
AAFEX II Engine Performance Results



No Measurable Differences in Engine Performance for the Fuels Evaluated

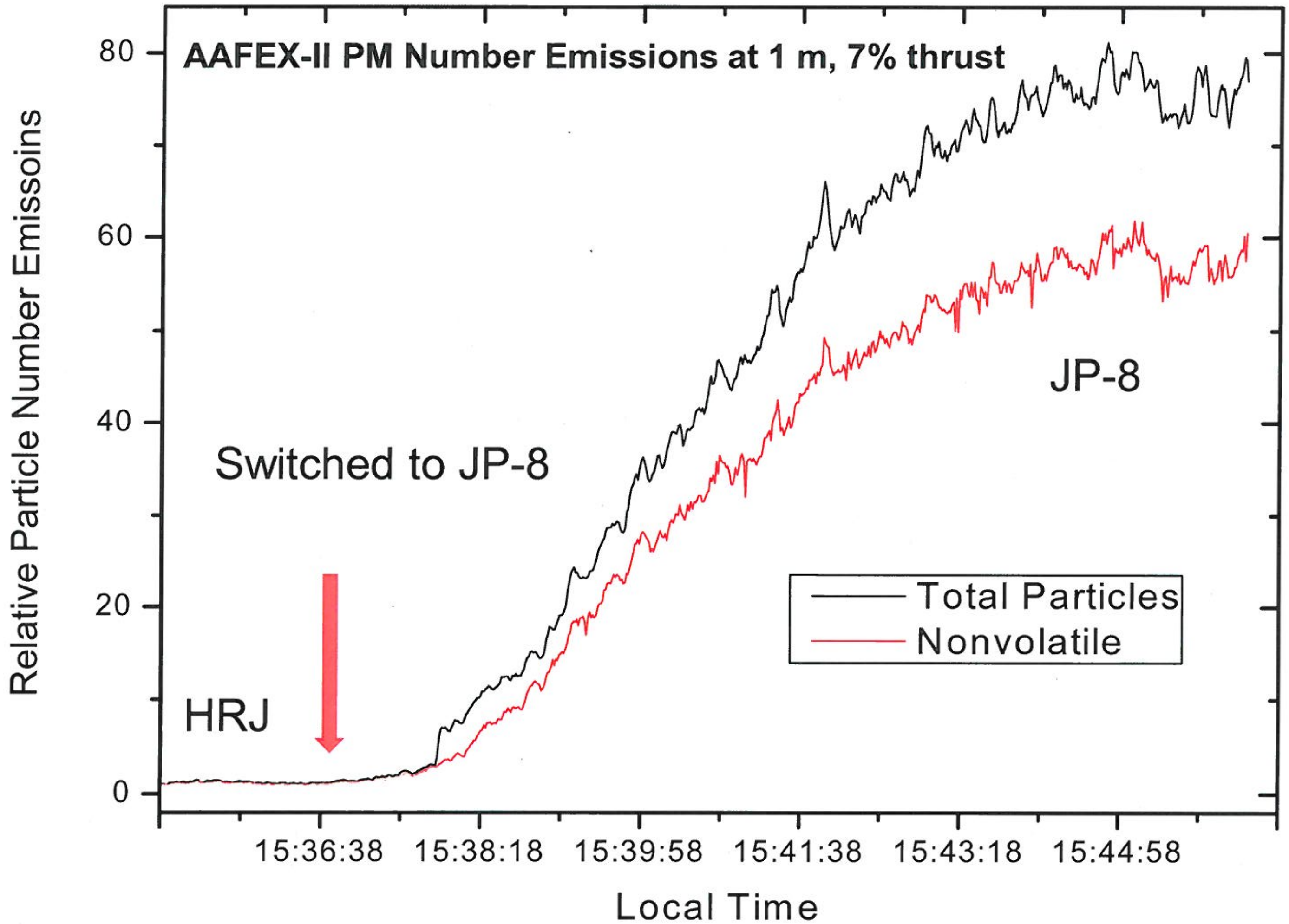
AAFEX II Neat Fuel Results





Neat Fuels Caused Leaks and Had Small Subtle Effects on Gaseous Emissions

AAFEX II Particulate Emissions Results



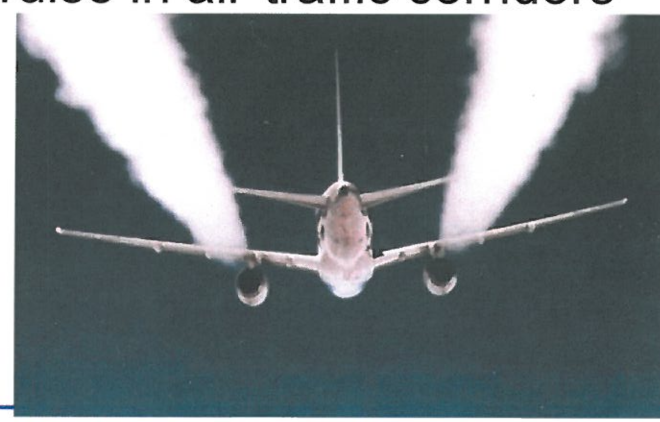
Alternative Fuels Substantially Reduce Particulate Emissions

AAFEX II Key Findings

- Negligible effect of fuel type on engine performance when compared on mass measurement basis and corrected for heating value within accuracy of measurements
- Slight reduction in NOX emissions at higher power conditions for F-T fuel
- Scatter in CO and HC emissions at idle and sub-idle due more to temperature effects than fuel type
- SO2 emissions correlated directly with Sulfur in the fuel as expected
- Fuel leaks encountered with neat HRJ and F-T fuels
- Large reductions in combustion-generated particulates with HRJ fuels. Larger reduction at lower power settings but some reductions also noted at higher power
- Reduced fuel sulfur in the alternative fuels also reduced aerosol formation in the aircraft exhaust plume

ACCESS Objectives

1. Characterize fuel effects on aircraft particle and gas phase emissions at cruise altitudes
2. Examine the evolution (growth, changes in composition/microphysical properties) of exhaust and contrail particles as plumes age and become mixed with background air.
3. Investigate the role of black carbon concentrations and properties and fuel sulfur in regulating contrail formation and the microphysical properties of the ice particles.
4. Survey black carbon and gas-phase emissions and contrail properties from commercial aircraft at cruise in air-traffic corridors



Chase Aircraft In Situ Measurements

Gas Phase
- CO_2 , H_2O, NOx, CO, Detailed Hydrocarbons (can samples)

Aerosols
- Total and nonvolatile number densities and size distributions
- Black carbon mass and size distribution

Clouds
- Particle size distributions and images
- Ice water content
- Extinction coefficient

Aircraft/State Parameters
- Total and static P and T
- Forward video
- 3D winds

Coordination with AEC Roadmap

- **AEC Roadmap is a clearinghouse of information about aviation PM research**
  - Serves as a source of information on policy drivers, findings from emissions research projects, current knowledge gaps, and plans for future research
- **Topics addressed at annual meeting held May 15-16, 2012 in Washington, DC include:**
  - Policy issues
  - Health impacts
  - Climate impacts
  - Volatile PM & secondary pollutants
  - Current emissions research
  - Emissions source characterization
  - Modeling & measurements
  - Mitigation strategies
  - Future research
- **Presentations provide data for evaluating and refining targets presented in the Technology Standing Committee's Table 1 and 1.1**.
- **AEC Roadmap meeting also provided an opportunity to discuss scope and goals of NASA's upcoming ACCESS project**
  - ACCESS is NASA's planned flight test of alternative fuels
  - Objectives include defining effect of alternative fuels on engine performance, PM emissions, and gas phase emissions
  - ACCESS is scheduled for 2013

Coordination with CAAFI

- **CAAFI, the Commercial Aviation Alternative Fuels Initiative, coordinates sustainable alternative fuels development issues on behalf of the aviation industry**
  - Broad participation by governmental agencies and the military, airlines, aircraft manufacturers, engine manufacturers, technology developers, agricultural interests, and others
- **Recent developments and topics of interest within CAAFI include:**
  - Fuel readiness
  - Feedstock readiness
  - Environmental progression/fuel sustainability
  - Fuel certification
  - Supply security
  - Commercialization progress
  - Economic improvement
- **Technology Standing Committee monitors developments on several topics within CAAFI**
  - Alternative fuel production pathways
  - Alternative fuel quality
  - Emissions and environmental impacts
  - Fuel and technology readiness
- **Data from CAAFI potentially useful for evaluating and refining targets presented in the Table 1.1.**

IPSA – TSC Discussion

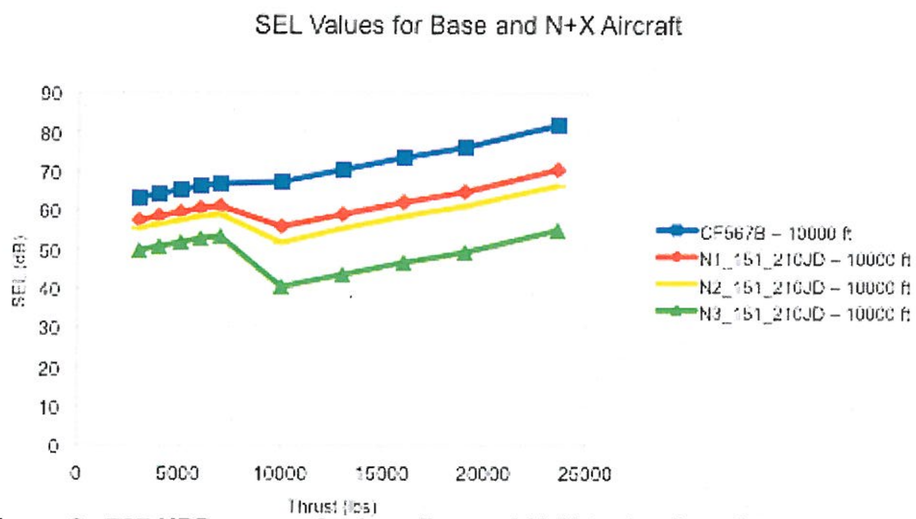


Figure 2. 737 NPD curves for baseline and N+X technology improvements.

Summary of Discussions: Through a series of discussions, emails, etc. with TSC and others, several key points were identified:

- •The TSC recommendations were really done considering what was likely going to occur for N+1 technology improvements, not so much for N+2 and N+3.
- •Since the approach configuration is much "dirtier" than the departure (landing gear are deployed, and flaps are deployed much further), it is not surprising that a slight "bump" is seen going from the highest thrust setting for approach (20000 pounds) for the 747 at N+3 level of improvement.
- •However, the more significant dips seen for the 737 are likely not credible, especially the N+3 curve, where the SEL for the highest thrust setting on departure (~24000 pounds) barely exceeds that for the highest thrust setting for approach (~7000 pounds).

Path Forward: Given the above, the recommendation is to keep the current single aisle analysis approach for N+1, but switch to the same approach as for the twin-aisles for N+2 and N+3.

N+3 Noise Goal Assessment

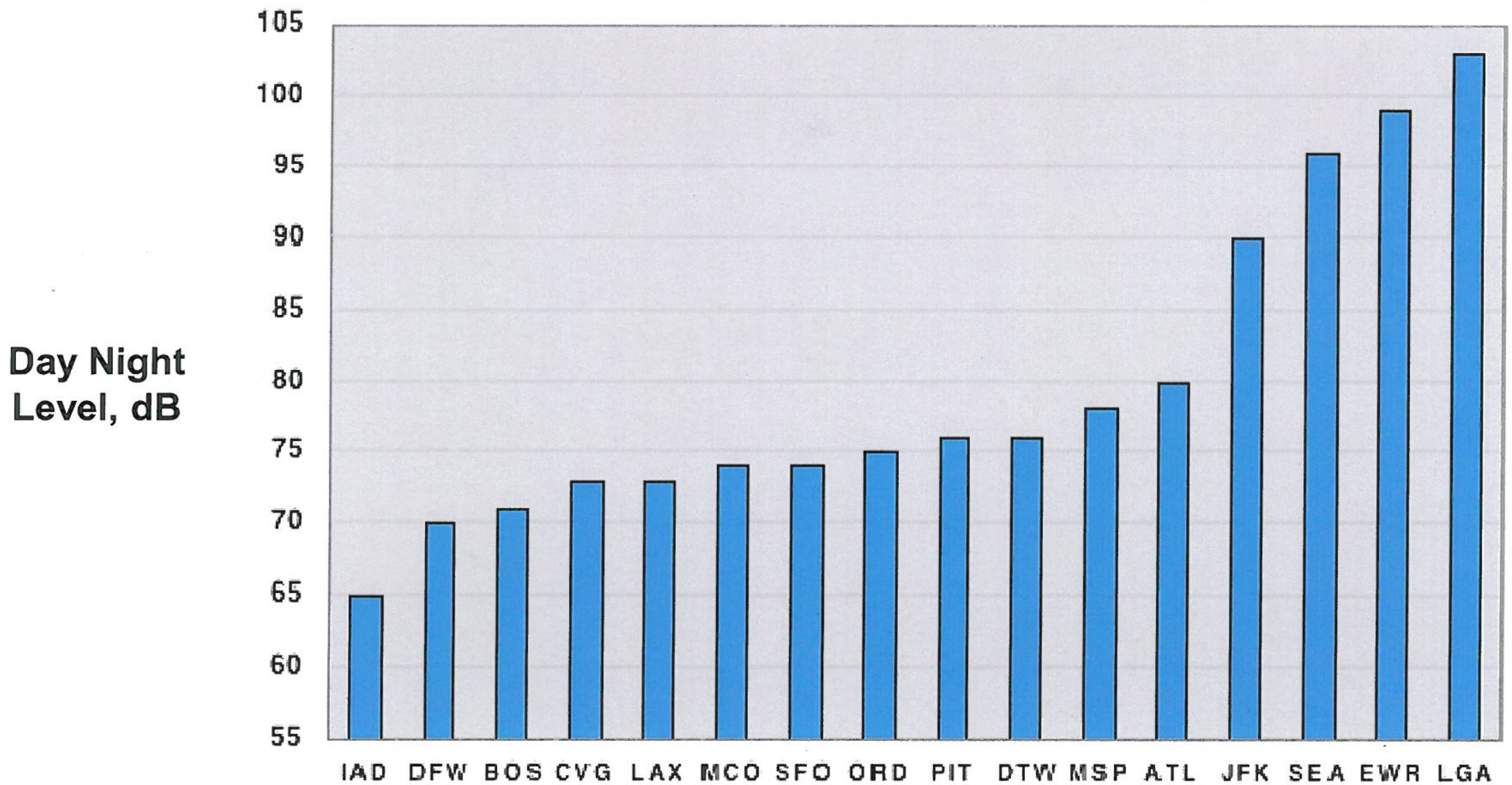
Mike Marcolini & Kevin Shepherd (NASA LaRC)
Terry Thompson (Metron Aviation)

Acoustics Technical Working Group
October 23, 2012

Background

- Current N+3 goal is Stage 4 – 71 dB
  - TRL 4-6 in 2025
  - Estimated noise reduction that would confine the 55 dB DNL contour to the “average” airport boundary

Projected 2005 Noise Levels at Airport Boundaries



Objective

- Examine an alternative approach to setting a N+3 noise goal
    - Population-based, instead of “area” based

- Quantify the noise technology necessary to reduce the population exposed to DNL of 55dB or greater by an order of magnitude relative to 2010 baseline

Approach

- Leverage/utilize the existing JPDO/IPSA analysis "infrastructure" to the maximum extent possible
- Use FAA approved model (NIRS—Noise Impact Routing System) to compute DNL contours
- 2010 baseline fleet and schedule for 55 CONUS airports
- "Bin" the aircraft fleet into a small number of classes based on seat count
- Select a representative aircraft for each class having noise cert values that are typical of best in production today

Approach (cont.)

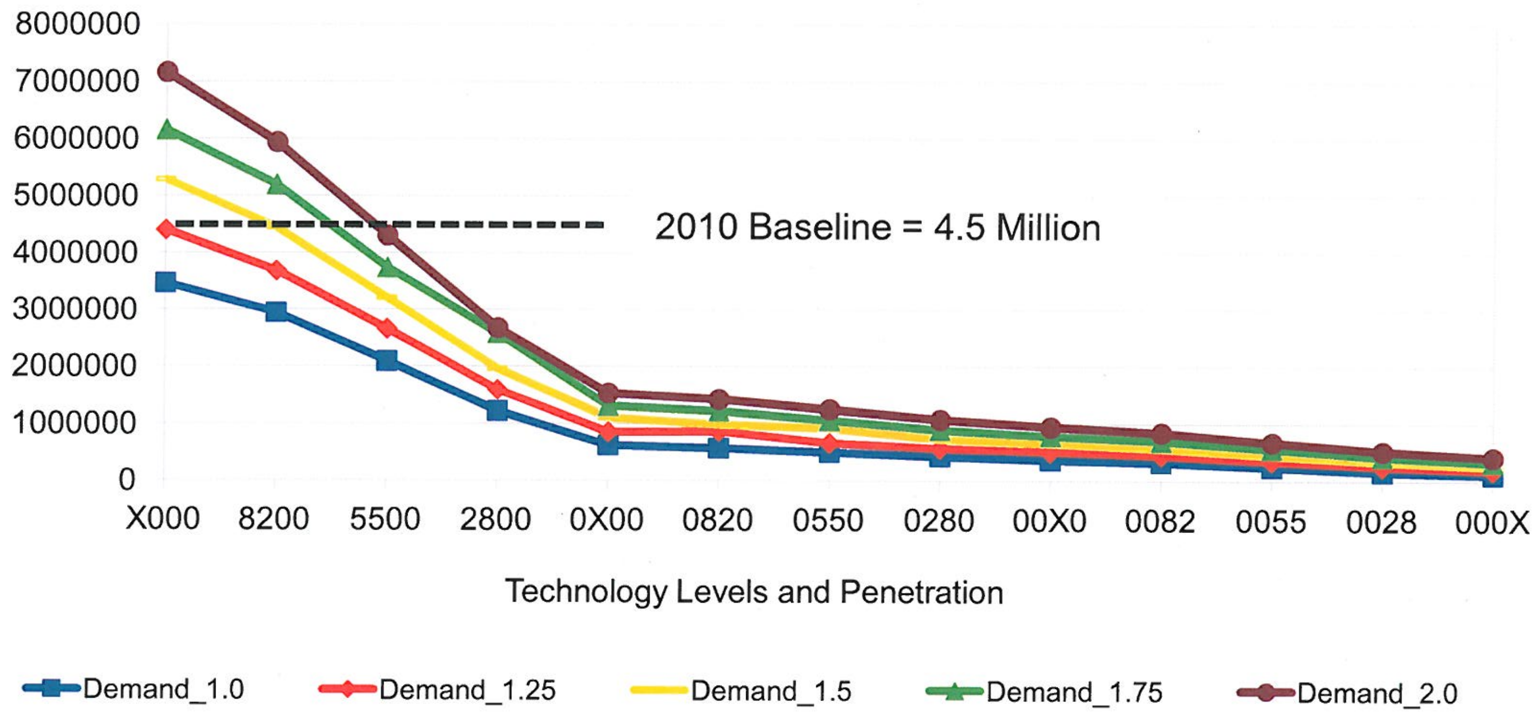
- Technology improvement benefits (i.e. Stage 4 – K) applied to a/c class representatives

- Compute population within DNL 55 and 65 dB contours at 55 airports
    - 2010 Baseline, actual fleet
    - 2010 Baseline, "best in fleet" (with and without growth)
    - N+1 fleet (K=32) (with and without growth)
    - N+2 fleet (K=42) (with and without growth)
    - N+3 fleet (K=71) (with and without growth)

- Examine "mixed" fleets (e.g. 50% N+1, 50% N+2)

Sample Result

Aggregate Population Exposed to Above 55 dB DNL



<u>Technology Level Code</u> (Number represents 10 x proportion; X = 100%)

1st character: TSC (Stage 4 – 10dB for twin aisle a/c; Stage 4 – 5 for all others)

2nd Character: N+1 (Stage 4 – 32 dB)

3rd character: N+2 (Stage 4 – 42 dB)

4th character: N+3 (Stage 4 – 71 dB)

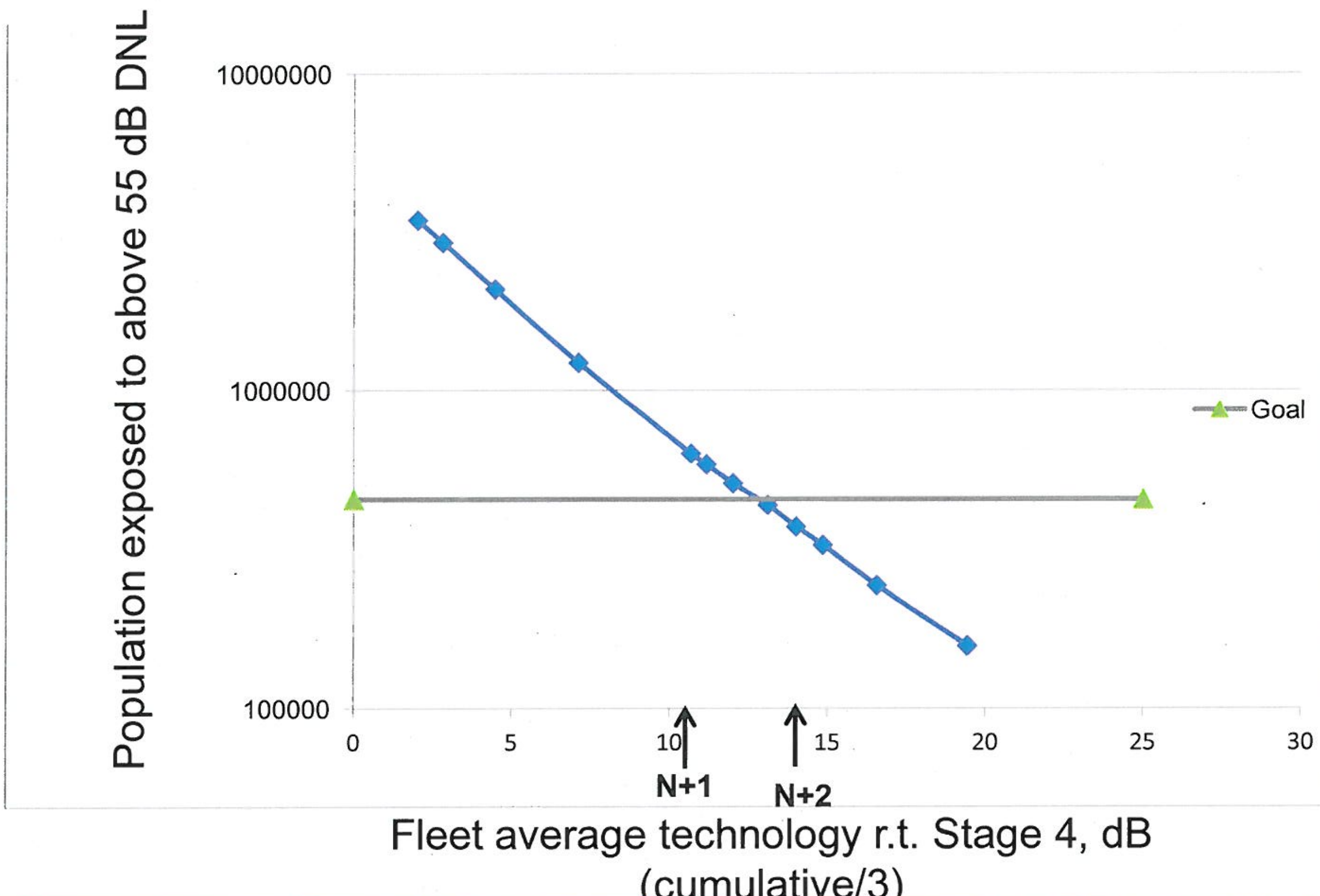
Example: “0550” = 50% N+1 aircraft and 50% N+2 aircraft

Recall the objective:

Quantify the noise technology necessary to reduce the population exposed to DNL of 55dB or greater by an order of magnitude relative to 2010 baseline

4.5M people were at or above 55 dB in 2010. Thus goal is 450k people exposed to no more than 55 dB.

Population above DNL 55 vs. nominal noise reduction (no growth)



Derivation of proposed population-based N+3 goal:

The N+3 goal is "Noise technology needed in 2025 at TRL 6 to meet target reduction in exposed population"

Technology at TRL 6 in 2025 is assumed to drive "fleet average" noise levels in 2050.

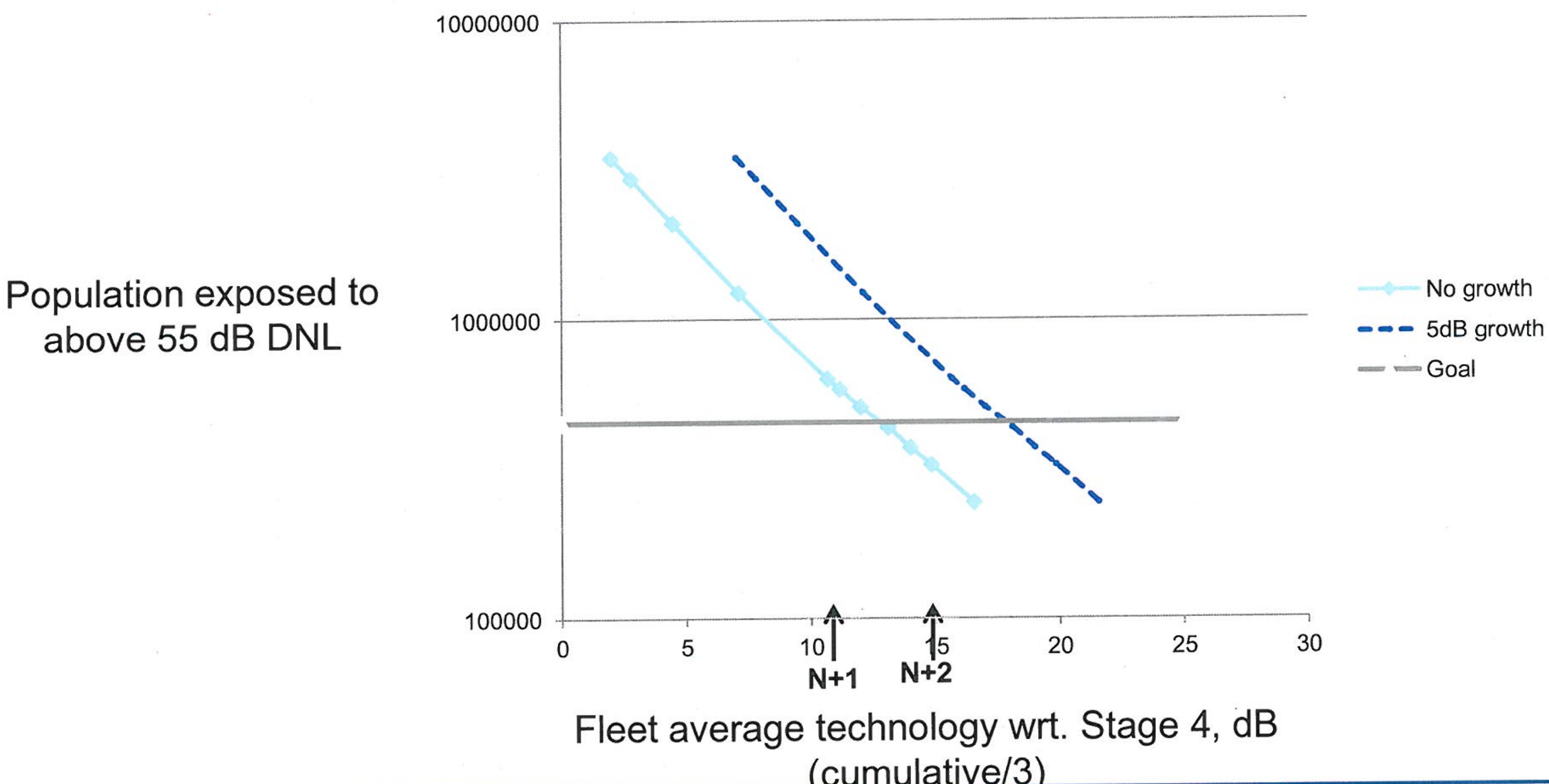
Thus, the 2025 goal needs to incorporate anticipated growth from 2010 to 2050.

Metron analysis indicates that Stage 4 – 37 dB (cum) will reduce exposed population to 450k, with no fleet growth.

2% growth over 40 years ~ 3.3 dB (not cum)
3% growth over 40 years ~ 5 dB
4% growth over 40 years ~ 6.6 dB

Conclusion: Technology needed in fleet in 2050:
No growth, Stage 4 – 37
2% growth, Stage 4 – 47
3% growth, Stage 4 – 52
4% growth, Stage 4 – 57

Population vs. nominal noise reduction



Conclusions

- Based on the following simplifying assumptions:
  - 55 CONUS airports represent total aircraft noise impact
  - Future noise reduction technology is applicable to all aircraft classes
  - Unrestricted future growth at all airports
  - No changes in operational procedures, fleet mix, day/night distribution, etc.
  - 3% annual growth in aircraft traffic

- Proposed N+3 goal is Stage 4 – 52 (cum): technology to be at TRL 6 in 2025 in order to reduce population exposed to DNL 55 dB or greater by 90% in 2050

- The proposed N+3 goal represents an improvement in production a/c noise levels from about Stage 4 – 6 (in 2010) to Stage 4 – 52 (in 2050)
  - This is a challenging goal, requiring an additional 10dB beyond the historical rate of 0.9 dB/year (itself a challenge to maintain!)

Issues/Needs

- Adjusting to new EDG structure.

Summary

- FY13 will include monitoring NASA activities in noise reduction technologies, Alt fuels analysis and flight testing, and AEC, CAAFI and CAEP processes and information.